Doctorant F/H Anatomical and microstructure informed tractography for connectivity evaluation

The offer description below is in French

Contract type: Fixed-term contract
Level of qualifications required: Graduate degree or equivalent
Fonction: PhD Position

About the research centre or Inria department

Le centre Inria Rennes - Bretagne Atlantique est un des huit centres d'Inria et compte plus d'une trentaine d'équipes de recherche. Le centre Inria est un acteur majeur et reconnu dans le domaine des sciences numériques. Il est au cœur d'un riche écosystème de R&D et d'innovation : PME fortement innovantes, grands groupes industriels, pôles de compétitivité, acteurs de la recherche et de l'enseignement supérieur, laboratoires d'excellence, institut de recherche technologique.

Context

Diffusion MRI (dMRI) quantifies the diffusion of water molecules (constrained by their environment), enabling us to infer a number of microstructure parameters, such as the arrangement of nerve fibers, the different tissues making them up and their properties (axon diameter, proportion of neuronal cell bodies, etc.). Additionally, dMRI combined with white matter tractography techniques is a highly promising method for assessing the trajectories of nerve fibers in the brain. More specifically, tractography (illustrated in figure 1) utilizes the directionality of diffusion of water molecules in brain tissue to estimate neuronal fiber orientation [D. Jones, 2010]. This process is known as fiber tracking or fiber tractography, and the resulting collection of white matter pathways is referred to as tractograms [Mori and Van Zijl, 2002]. These approaches have the remarkable capability to delineate white matter fiber pathways, offering unprecedented insights into the structural connections within the human brain. They hold enormous potential for studying brain anatomy, development, and function [Jeurissen et al., 2019a]. Furthermore, tractography has demonstrated its substantial worth in the field of neurosurgery, playing a pivotal role in surgical planning, particularly in the preservation of critical white matter pathways during brain resections [Mancini et al., 2019].

Despite advancements in dMRI acquisition and tracking methods, white matter fiber tractography continues to grapple with certain limitations. Recent studies reported the existence of a significant number of connections that remain undetected by tractography, resulting in false negatives [D. B. Aydogan et al., 2018]. This issue poses a critical challenge, particularly in applications like surgical planning. Furthermore, the outcomes of other studies indicate that state-of-the-art tractography algorithms produce substantial numbers of false positives as well [K. Maier-Hein et al., 2017b]. This drawback hampers the accurate exploration of network properties within the brain's connectome [Zalesky et al., 2016].

Despite this, such tractography approaches remain limited for a variety of reasons. Firstly, most of the studies use a simple diffusion model such as diffusion tensor imaging (DTI), which cannot estimate fibers with different orientation in one voxel in complex areas. Moreover, the interpretation of changes in the measured diffusion tensor is complex and should be performed with care. Furthermore, the estimation of cerebral fibers (tractography [8], illustrated in figure 1) is not yet reliable. Studies have shown that the most advanced tractography algorithms tend to generate a large number of fiber bundles, resulting in a high false-positive rate. In this thesis, our aim was to propose innovative methods for improving fiber estimation.

To overpass that, new approaches have been proposed that include anatomical a priori to guide the algorithms in complex regions. In the Empenn team, we recently developed methods for creating and combining anatomical a priori using Riemannian geometry, applicable to any orientation distribution function (ODF)-based tractography algorithms.

Assignment

This PhD will focus on two major subjects:

- Improving the atlas creation using multi-atlasing in order to take into account the tractogram variability
- Improving a priori estimation using microstructural features to guide tractography, proposed during
the PhD thesis of Thomas Durantel, by taking into account the variability of track orientation and the TOD estimation.

- Incorporation of anatomical a priori - fiber bundle atlas, microstructural information from relaxometry or diffusion imaging along known, manually delineated fibers - and data to help tractography and avoid false positives.

**Main activities**

The proposed method will be based on the track orientation distribution (TOD) [Dhollander et al., 2014] from an atlas of segmented fiber bundles and incorporates it during the tracking process, using a Riemannian framework. The developed approach will be tested on a cohort of patients suffering from depression, with the aim of better estimating the microstructure and thus better understanding the neuronal modifications caused by this disease.

**Skills**

We look for candidates strongly motivated by challenging research topics in neuroimaging. The applicant should present a good background in applied mathematics. Basic knowledge in image processing would be a plus. Good knowledge of computer science aspects is also mandatory, especially in Python and C++.

**Benefits package**

- Restauration subventionnée
- Transports publics remboursés partiellement
- Possibilité de télétravail à hauteur de 90 jours annuels
- Prise en charge partielle du coût de la mutuelle

**Remuneration**

Salaire mensuel brut 2100€ les 2 premières années et 2200€ la troisième.

**General Information**

- **Theme/Domain**: Computational Neuroscience and Medicine
- **Biologie et santé, Sciences de la vie et de la terre (BAP A)**
- **Town/city**: Rennes
- **Inria Center**: Centre Inria de l'Université de Rennes
- **Starting date**: 2024-09-01
- **Duration of contract**: 3 years
- **Deadline to apply**: 2024-06-30

**Contacts**

- **Inria Team**: EMPENN
- **PhD Supervisor**: Coloigner Julie / julie.coloigner@irisa.fr

**About Inria**

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- goûts et appétences,
- domaine d'excellence,
- éléments de personnalité ou de caractère,
- savoir et savoir faire transversaux...

Cette rubrique permet de compléter et alléger (réduire) la liste plus formelle des compétences :

- "Se sentir à l'aise dans un environnement de dynamique scientifique, aimer apprendre et écouter
sont des qualités essentielles pour réussir cette mission."
• "Passionné(e) par l’innovation, avec une expertise dans le développement Ruby on Rail et une grande capacité de conviction. Une thèse dans le domaine *** constitue un réel atout."

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Instruction to apply

Merci de déposer en ligne CV, lettre de motivation et éventuelles recommandations

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